

THEMATIC AREA:

CLIMATE CHANGE

(Impacts, Downscale/Coupled Modeling, Adaptation)

MISSION: *Create an effective adaptation strategy for climate change based on the best available science.*

[Science objective] Provide the best available predictions of how the regional climate might change, and estimate the impacts those changes might have on the region's natural and cultural resources (in order).

[Management objective] To work with partners and stakeholders to determine adaptation and mitigation strategies that can be implemented and coordinated at a regional scale.

A. HEADING: REGIONAL LEVEL

1. PROGRAM: Landscape-level Disturbances & System-level Response

Examines major disturbances (includes climate change) as well as the impacts associated with these, regardless of ecological organization (e.g., community, species, population).

PROGRAM DESCRIPTION: *Project likely impacts climate change will have on the AppLCC, how those changes could affect the region, and work with partners to develop strategies to help human communities, industry, aquatic species and other conservation management interests, plan for, and adapt to those changes.*

(Grouping) – Foundational/Stock-taking Assessment/Classification System

- **Project Description:** Develop a data catalog “Database of databases” to document historic or current long-term datasets being collected in the region.
 - o **(related) Project Description:** Archive important regional data that may be lost (e.g. such as SAMAB, or University research data sets). *[COP Comment: This may include local human history and obscure gray literature / newspaper / published histories that give information about previous vegetation, human activities. Many sources have not reached academic, geographic or ecological literature / databases.]*
 - o **(related) Project Description:** Develop a catalog of important climate publications; subset of the national work.
 - o **(related) Project Description:** Index technology and availability of ecologically scalable habitat-type focused imagery data (veg/forest types, talus, boulder or ground types, wetlands/water body) for application in species/habitat range and

habitat modeling/shifts.

[AppLCC FY 11-12 Funded Project (Baldwin, Clemson University) “Data Needs Assessment, to Support Conservation Planning for the Appalachian LCC”]

- **Project Description:** Develop a common set of parameters and data standards to facilitate integration of multi-agency/organization restoration, protection, and management (geo) databases into a more comprehensive conservation tracking system to: monitor land use land cover changes, refine decision support tools, and serve as sampling universe to test underlying assumptions.
- **Project Description:** Coordinate with the National Climate Assessment to build an indicator system that detects key climate change trends in the Appalachian LCC related to changes in land use, air and water pollution, water supply and demand, species and habitat ranges, pathogen and invasive species vectors, snowpack, and adaptation/response efforts.
- **Project Description:** Identifying/prioritizing species (population-level) or habitats (system-level) most at risk of effects from climate change, and developing subsequent management activities.

[AppLCC FY11-12 Funded Project (Young & Sneddon, NatureServe) “A climate change vulnerability assessment that will both assess CCVA methods in use, and identify vulnerable species and habitats within Appalachia”]

(Grouping) – *Climate Change Science and Abiotic or Mechanical Aspects*

- **Project Description:** Measure and model hydrologic regime changes related to climate change, including changes in water quality (temperature, chemistry) and quantity (storm intensity, floods, loss of stream baseflow, groundwater recharge, soil moisture, drought) to understand the impact of precipitation and temperature change on surface-water and groundwater hydrology in the context of regional land use, water use, recreation, industrial, municipal, agriculture, providing a needed basis for creating and synthesizing additional information on impacts to human and ecological systems. [COP Comment: *I imagine that changes in hydrology and soil moisture would be modeled with the Variable Infiltration Capacity (VIC) model by Cherkauer, or a similar complex process model.*]
- **Project Description:** Measure and track inter-annual variations in snow pack to support analysis of effects on high elevation species. [COP Comment: *This is very important, but difficult to measure. Monitoring snow depth requires physical measurements to be made at permanent plots. Most snow data is about snowfall, which is calculated from precipitation and temperature variables. Funding snow pack monitoring in an experimental design would be a good project.*]

(Grouping) – *Climate Change Impacts on Ecological Function and Response to Changes*

- **Project Description:** Characterize soil processes and chemistry changes due to changes in temperature and precipitation/moisture (as related to climate change). Identify parameters for highly vulnerable soils and map these areas (soil type, slope, position, elevation, land use). *[COP Comment: The effects on soil may be profound and have great effect on capacity to support vegetation types and fossorial species.]*
- **Project Description:** Examine how nutrient dynamics are influenced by climate change.
- **Project Description:** Use remote sensing technology to identify impact of climate change on edge habitat and migration corridors. *[COP Comment: I think the work of the USDA FS with ForWarn can get us there sooner rather than later with existing projects.]*
- **Project Description:** Apply landscape simulation models (e.g., LANDIS) that predict spatial and temporal dynamics of land-use/land cover under alternative scenarios (e.g., climate change, urban growth, energy development). *[COP Comments: Land cover changes are also going to be dependent on soil changes; These are very useful in combination with impact models (e.g., Tree Atlas) as a complementary approach to exploring forest impacts especially. Other impact- or process- modeling efforts can also add to the robustness of the information we inform our decisions with (VIC, PnET, etc.); Need more ground-truthing. Often the important elements / species are not well-detected by aerial views / ecosystem or forest typing. These may be the most sensitive for changes.]*
[COP Comment: I feel the three projects immediately above could be rolled into one, but the focus should be on changes to soil chemistry/hydrology/nutrient cycling. None of the models (that I'm aware of) that predict tree/plant species change (shift) as a function of climate change take into account soil types and processes. Plant species distribution is as much a function of soils and hydrology as temperature (if not more so), so I feel it's critical to consider how climate change will affect soil properties.]

(Grouping) – *Energy and Related Infrastructure and Roads*

- **Project Description:** Assess the relationship between climate change, energy development, and water-dependent socioeconomic sectors to inform regional and state-level energy and water use policies.
- **Project Description:** Compile comprehensive/validated road/transportation maps/data layers (for use in corridor, connectivity, invasive species analyses etc.).
- **Project Description:** Identify best management practices that are currently being used by land managers to increase energy efficiency and sequester carbon.
- **Project Description:** Use EPA and NRCS to develop a baseline of best management/ conservation practices/ systems.

(Grouping) – *Urbanization, Population Growth and (Domestic or Industrial) Water Demands*

- **Project Description:** Identify current land management practices and vulnerable ecosystem services.
- **Project Description:** Develop an electronic model and template that will allow for the ongoing assessment and evaluation of water quality and quantity for the LCC's freshwater resources, the human uses of those resources, and current or future conflicts between human and fish and wildlife needs for water.
- **Project Description:** Design a working model to identify the use and inter-dependency of water supply, and limiting factors contributing to potential future shortages to meet human and ecological needs.
 - o **(related) Project Description:** Identify barriers and promote strategies focusing on maintaining drinking water in the Southeast.

(Grouping) – *Agricultural Expansion and (Ag-related) Water Demands*

- **Project Description:** Identify current conservation practices on private lands focusing on irrigation management and other related agricultural water practices.
- **Project Description:** Document the quantity and quality of water on agricultural lands in light of urban encroachment on rural landscapes. Obtain data from local state and Federal agencies along with non-profits to identify the number and types of small-specialized agricultural operations that impact water resources.

(Grouping) – *Effects of Air Pollution*

- **Project Description:** Establish long-term monitoring of air quality parameters across Appalachian LCC due to acid deposition, mercury, sulfur, and ozone.

(Grouping) – *Cumulative Impacts*

- **Project Description:** Develop guidelines and principles for creating adaptation strategies. Develop an organized approach to developing relevant strategies, from adaptation concepts to adaptation actions, to provide a clear process.
- **Project Description:** Evaluate the interaction among land use, climate change, invasive species, and/or other environmental stressors to develop strategies for adaptation. Strategies: human interactions, biological augmentation, genetic banking, and restoration efforts.
- **Project Description:** Conduct a detailed literature search to identify the cumulative impacts of lost ecosystem services.

B. HEADING: HUMAN DIMENSIONS

2. PROGRAM: Social Component

(Grouping) – *Value/Ecosystem Services and Conflict*

- **Project Description:** Support economic and cultural analyses related to decision-making about land use, land management, water resources, ecosystem services, and how these sectors respond to changes in the climate system.
- **Project Description:** Map or develop overlays of the human populations and demographics at the specific geographic local in order to develop most effectively information and education-outreach strategies. Most specifically, it is important to develop a socioeconomic profile at local levels that have been identified as having vulnerable species, populations, or are where climate estimates indicate significant adversely impacts – or significant resilience – related to climate change.
- **Project Description:** Support a multi-scale vulnerability assessment to identify human populations, inhabited geographic areas, and infrastructure or other human interests that would be most vulnerable to climate change in the LCC (i.e. a climate vulnerability assessment for humans).
- **Project Description:** Assemble climate change scenario planning methods to support policy development at local levels and to broaden civil society’s understanding of a changing climate.
- **Project Description:** Develop, administer and analyze a survey instrument to determine regional public attitudes, values, and opinions related to wildlife and natural resource conservation across the Appalachian LCC.
- **Project Description:** Develop a customized internal and external information dissemination plan including messages and strategies for all stakeholder groups- public citizens, public officials, program managers and others. Determine methods to communicate complex technical issues to multiple stakeholders including decision-makers, especially information about ecosystem services.
- **Project Description:** Conduct opinion surveys to determine the public’s preferences and priorities in regards to management of natural resources and ecosystem services.
- **Project Description:** Conduct an economic assessment to demonstrate the opportunity cost of losing our natural resources and ecosystem services. Also include an economic analysis to examine land use stressors and the community benefits of stream and wetlands restoration.

- **Project Description:** Research and analyze economic valuation of goods and services provided by native bivalves.

(Grouping) – *Recreational, Commercial, Subsistence Use*

- **Project Description:** Determine climate impacts on Recreation.
- **Project Description:** Determine climate impacts on Subsistence.

C. HEADING: SYSTEM LEVEL

3. PROGRAM: Ecological Functions of Managed/Human-Altered Systems

(Grouping) – *Foundational/Stock-taking Assessment/Classification System*

(Grouping) – *Barriers (flows and species movement)*

(Grouping) – *Mitigating Ag and Forestry Impacts*

- **Project Description:** Develop/compile best practices for forestry and agriculture that reduce vulnerability and build resistance and resilience to negative climate change impacts across the landscape. This should be done in cooperation with agencies that have extension worker networks such as NRCS, state forestry departments, and/or farm bureaus.
- **Project Description:** Develop a socioeconomic profile of human populations managing the impacted natural resource base.

(Grouping) – *Protection & Restoration Approaches*

- **Project Description:** Develop a common set of parameters and data standards to facilitate integration of multi-agency/organization restoration, protection, and management (geo) databases into a more comprehensive conservation tracking system to: monitor land use land cover changes, changes in human populations, refine decision support tools, and serve as sampling universe to test underlying assumptions.

4. PROGRAM: Ecological Functions of Natural/Intact Systems

(Grouping) – *Foundational/Stock-taking Assessment/Classification System*

- **Project Description:** Compile consistent land-use/landcover classification and mapping using common ecological systems or similar nationally consistent classification system, ideally with 5-year updates. *[COP Comment: This is being discussed/addressed among the broader LCC community in cooperation w/ the NAWMP NSST.]*

- **Project Description:** Compile updated, complete and coordinated land cover data (NLCD, NWI, etc.).
- **Project Description:** Increase use/availability of LIDAR technology and infra-red mapping in water/land thermal mapping (temporal/spatial applications for aquatic, wetland terrestrial habitat etc.).
- **Project Description:** Compile consistent secured (protected) lands spatial data system that allows assessment of lands and habitat types in the conservation estate. The system should include both public and private lands (conservation easements), and should be updated annually. (Purpose: Needed for analysis of how well habitats are represented in the conservation estate.)
- **Project Description:** Assemble existing vegetation plot/releve data from the region in a central database (e.g., VegBank) so that it is accessible for quantitative analyses of species and habitat distribution, range shifts, and environmental requirements/tolerance. Existing vegetation plots within the Appalachian LCC likely number well over 10,000. Encourage plot sampling of data-poor habitat types.

[COP Comments: All of the projects mentioned above in 4. are cross-cutting, needed for all Portfolio Themes and in fact are not either limited to climate change or very closely aligned with the stated program description of Ecological Function. Having said that though I feel the standardization, rapid deployment of updates, and standard classification schemes is the most critical thing we need on the ground but requires National-level coordination and planning. Lastly, planning for updates to keep the information relevant should be a critical element of any project or effort.]

(Grouping) – Effects of Fire on Ecosystems

- **Project Description:** Work with federal, state and local partners to assess conservation practices related to fire and prescribed burning.
- **Project Description:** Assess human populations that are most vulnerable to increasing temperature and fire- characteristics of the population such as age, transportation routes to and from fire hazard areas.
- **Project Description:** Work with NRCS as partner to determine areas that use prescribed burning as a conservation practice.

(Grouping) – Relationship/Ecological Flows and Nutrient Dynamics

- **Project Description:** Assess impacts on species range shifts and losses of ecosystem function related to changes in climate parameters including extreme weather events, water/ fire regimes, food availability and nutrient cycles.

- **Project Description:** Research carbon source and sink dynamics of natural sites and common management practices. Deepen understanding of the relationship between the fate of human-induced and natural carbon emissions, and subsequent uptake and storage by the terrestrial biosphere.
- **Project Description:** Stream classification system and subsequent geospatial data used to quantify the amount and types of streams and rivers allowing conservation partners to better allocate conservation actions and resources, and recommend flow and hydrology policies and management actions for streams that lack site specific data.

[AppLCC FY11/12 Funded Project (Anderson et al., The Nature Conservancy & ORNL) “A Stream Classification System for the Appalachian Landscape Conservation Cooperative”]

(Grouping) – *Ecosystem Integrity/Resiliency*

- **Project Description:** Coarse-filter assessments of ecological integrity, connectivity, and resilience to complement priority species approach and which would support land acquisitions, conservation investments, and planning. *{Examples include CAPS in Massachusetts and Geophysical and Resilient System Approach to Climate Change Adaptation proposed by TNC in the Northeast.}*
- **Project Description:** Identify potential climate refugia inside and outside natural sites, where there is higher likelihood of maintaining biodiversity values (e.g., species, habitats, evolutionary processes).
- **Project Description:** Develop comprehensive models that consider terrestrial and aquatic conservation needs by incorporating an aquatic component (e.g. stream and river networks) into terrestrial landscape models.

D. HEADING: COMMUNITY LEVEL

5. PROGRAM: Community Level (Description and Function or Basic Community Ecology)

(Grouping) – Foundational/Stock-taking Assessment/Classification System

- **Project Description:** Update the National Vegetation Classification (NVC) with unique environmental descriptors to accompany floristic descriptions, in order to identify the range of ecological niches that should be conserved, even if species migrate and the natural communities become unrecognizable in terms of floristics. The NVC represents a key baseline index of the diversity of communities and environments in the Appalachian LCC. Upgrading the NVC to allow its use into the future is a key step in allowing science-based conservation to move forward. Habitats that have not yet been described in the NVC should be a priority for inclusion.

(Grouping) – Basic Ecology/Ecological Relationships

- **Project Description:** Assess the assumptions related to use of focal or representative species approach to guide development of decision support tools, i.e. do these approaches adequately represent larger sets of species and how do they compare to coarse-filter approaches.

E. HEADING: SPECIES/POPULATION LEVEL

6. PROGRAM: Basic Biological Understanding (Species-level)

(Grouping) – Foundational/Stock-taking Assessment/Classification System

- **Project Description:** Assemble and/or develop high resolution species range maps in a standard GIS format, with an emphasis on foundational species (e.g., red spruce), ecosystem engineers (e.g., beaver), climate indicator species (e.g., Lepidoptera or spiders that are known to move with climate), highly vulnerable species (e.g. high elevation amphibians), and other species or groups of interest. *{Nice example in Southeastern Naturalist 11(4):551-566 mapping Golden Silk Orbweaver occurrences moving northward since 1863}.*
- **Project Description:** Compile georeferenced species occurrence and population viability data in a central database (e.g., NatureServe Explorer), with updates on a yearly basis. Such data forms the basis for a broad base of quantitative and/or spatial assessments.

(Grouping) – Basic Biological Information

- **Project Description:** Identify critical thresholds in species' physiological tolerances and abilities to adjust or adapt to short term and long term habitat alterations caused by changing climate.
- **Project Description:** Develop an ecological health index for high elevation (and other at-risk) communities based on phenological variables (e.g. bud burst, migration timing, etc.).
- **Project Description:** Support a multi-scale vulnerability assessment (that incorporate species-specific physiological data) to identify habitats and species that would be most vulnerable to climate change in the LCC. (Coarse and fine scale). *[Notes: physiology includes environmental physiology, species specific data- what are the thermal tolerances, and seasonal cues for organisms, and when plugged into population models, the predicted impact on the population level processes.]*
 [AppLCC FY11/12 Funded Project (Young & Sneddon, NatureServe) "Understanding Land Use and Climate Change in the Appalachian Landscape "]
- **Project Description:** Identify effect of changing climate on species migration and distribution across the AppLCC; elevation and micro scale habitat related to aspect, elevation, etc. create opportunities for fine scale and macro scale changes and adaptation (like the specific location, timing, elevation, etc. of migrant species).
- **Project Description:** Landscape genetics-mine data from multi-species, multi-organizations to add as layers on landscape level spatial analysis. This will allow the identification of "genetic corridors" for obvious or cryptic movement of organisms, and "genetic hot-spots," or areas that multiple species have high levels of genetic diversity to facilitate biological planning; critical for our LLC given the preponderance of endemic or possible endemic trinomial and clines.
- **Project Description:** Species-habitat models that allow for the assessment of the capability of habitats to support populations at objective levels at present and in the future. Most existing species-habitat models do not allow for assessments of capacity, abundance or persistence/resilience. And for some fauna, no or limited models exist (herps). *[COP Comment: Suggest developing this as smaller a pilot/proof-of-concept type of project. Given all the species of endemics with restricted ranges in the Apps, this project could be helpful in addressing their conservation needs under climate change. I suggest that the modeling be done on select species that represent high-priority species in the LCC (e.g. one of the woodland salamanders, a migratory bird species, and maybe a small mammal species; should already be well studied and relatively abundant in the landscape (where it occurs – i.e. it's ok if it has a relatively small range), but also viewed as susceptible to/threatened by climate change.]*
- **Project Description:** Updated comprehensive population surveys-what are the current distributions, habitat preferences, and community /ecological necessities for organisms.

(Grouping) – *At-Risk Species/Populations & Endemics*

- **Project Description:** Assess climate change impacts on endemic and other native communities within the LCC including disease, range/habitat, breeding/spawning locations, and migration routes {esp. aquatics}. *[COP Comment: This is very broad. Rather than comprehensive surveys (for this climate change theme), I would rather see targeted research on thresholds in climate tolerance of species, as listed in one of the projects above.]*
 - o **(related) Project Description:** Establish endemic species, trinomial taxa, and unique genetic group population trends to investigate possible relationships to climate change influences.
 - o **(related From Aquatics) Project Description: [S]** Identify temp and flow tolerance limits of species and appropriate management technologies to improve the management of controlled systems to reduce impacts on downstream communities.
 - o **(related from Aquatics) Project Description: [N]** Assess aquatic species vulnerability to changes in stream flow and temperature, water quality. *[COP Comment: This CSC project on spatial and temporal variability of fishes in response to Climate Change may be a good guide for work related to benthics or other target species. <https://nccwsc.usgs.gov/display-project/4f8c648de4b0546c0c397b43/50070884e4b0abf7ce733fee>]*
 - o **(related from Aquatics) Project Description: [N]** Responses of populations to altered thermal /hydrologic regimes. *[COP Comment: Specify or ask the researcher to specifically target certain species or a group of species that are most likely at risk. Conversely, specify that this must be done for the most abundantly available biological data source—Benthic macro invertebrates across Appalachia.]*

(Grouping) – *Contaminants/Pollutants Effects on Species/Populations*

- **Project Description:** Work with federal, state and local agencies such as EPA and NRCS, and state agencies with parallel missions to obtain data relative to nutrient runoff and the human populations that have been targeted to reduce point and non-point source pollutants.

(Grouping) – *Invasive Organisms Effect on Species and Populations*

- **Project Description:** Identify impacts of changing climate on invasives including: zoonotic and wildlife diseases, exotic plant and animal distribution {esp. in forests and ranavirus and chytrid fungus}. Part of impact assessment would be predictive modeling to support early detection and rapid response action.

(Grouping) – *Effects of Disease (on a Species or Taxonomic Group)*

F. HEADING: “HOW (THE LCC) SHOULD DO BUSINESS”

- Participate in national enterprise systems through the networks of LCCs and Climate Science Centers (CSCs) that will compile information from multiple sources at larger relevant scales than the AppLCC. “Don’t build your own.”
- Work with partners to develop regional climate adaptation strategies that will, to the extent possible, help ensure the persistence of healthy human and fish and wildlife communities in the face of changing climatic conditions. Such strategies would reduce vulnerability to negative impacts, build ecosystem resistance and resilience, and improve landscape integrity and connectivity.
- Identify natural sources/examples of adaptation. (Species that are less sensitive to climate change serve as an example of strategies to manage throughout the LCC.)
- Serve as a clearinghouse to ensure that there is coordination and sharing of datasets and current climate change research products; host datasets and products that have no other established “home.” Link to existing clearinghouses, especially those that are national or international in scope, where possible. Link decision-makers to adaptation tools, data, and expertise that support adaptation decision-making. Foster proactive communication between the scientific community, decision-makers, and land managers. Support large-scale monitoring efforts to document and track impacts of climate change on Appalachia.

[2010-xx NASA/URI Funded Project] Mega-Transect - large-scale, multi-agency/research for climate change monitoring and impact studies (and 2012 NASA/NPS Funded Project) across the Appalachian and Rocky Mt Transect]

- Consider establishing and funding a full time social science position at the GS 12-14 level. The position should focus on establishing and sustaining working relationships in the form of inter-agency and inter-organizational networks. Often the missions of the various members of the network are similar to the goals and objectives of the AppLCC. Position requirement should focus on the fields of rural sociology and sociology, with a specific experience in community action research. The position should allow for short-term contracts establishing cooperative agreements with universities.
- Compile, develop, and make available consistent managed-lands spatial data and products.
- Identify institutional strategies to support adaptation to climate change, including revisions to legal codes and policy practices. Identify capacity-building needs of institutions and land managers and promote exchanges and training that result in an increase in their adaptive capacity.
- Explore ways that the activities of the LCC and its partners can become carbon neutral by reducing and/or offsetting the carbon emissions of their activities.

- The ability to think in terms of triage for the most vulnerable will unfortunately become more common and should then be underpinned with systems level planning for those changes, providing for corridors, larger landscape resilience etc.
- As with other thematic units the LLC can and should be the source for organizing the rapidly developing science and management trials and pushing that back out to planners and managers as fast as is possible and meaningful.